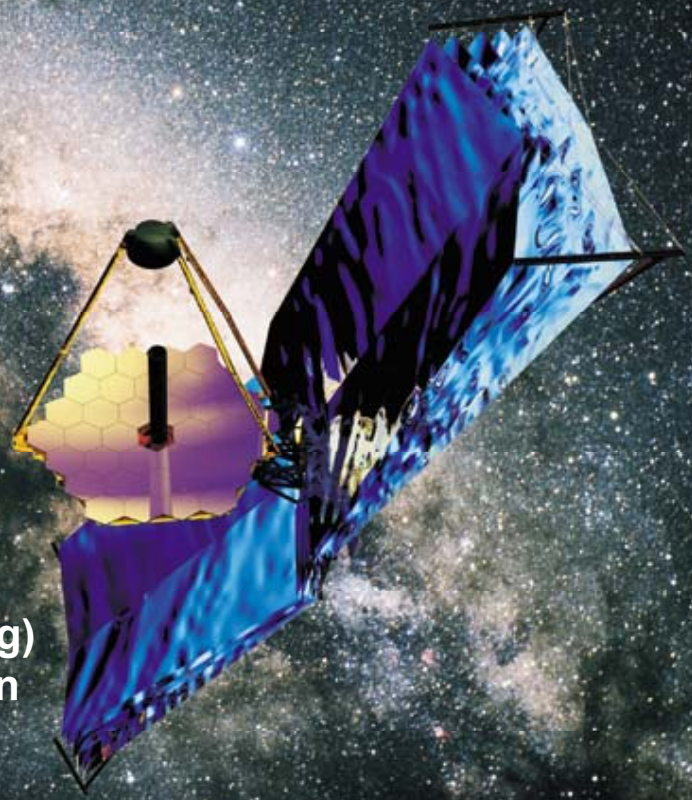
Origins Subcommittee

John Mather, JWST Senior Project Scientist



Project Manager:	Phil Sabelhaus
Deputy Project Manager:	John Decker (Acting)
DPM-Resources:	Jonathan G. Bryson
Senior Project Scientist:	John C. Mather
Prime Contractor:	NGST
Science Ops Center:	STScI
Public Web Site:	www.JWST.nasa.gov

October 24, 2003

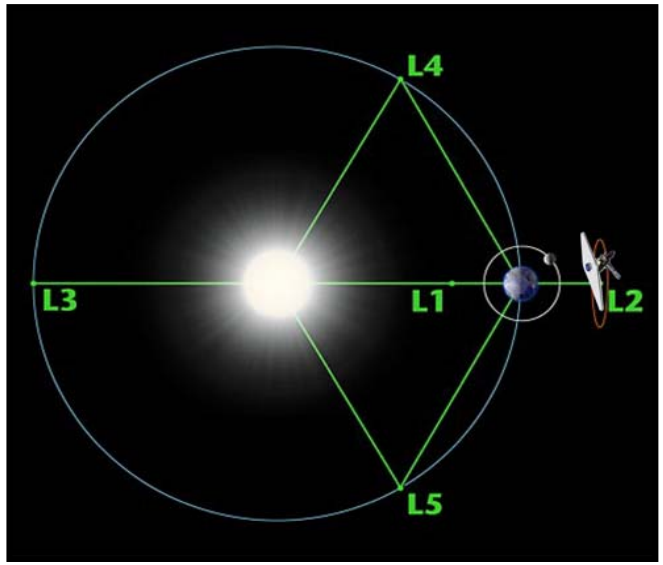
Agenda

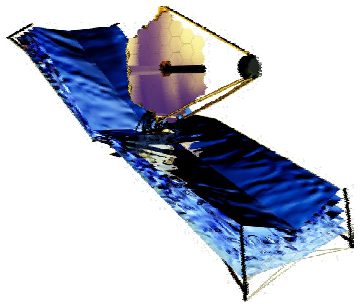
- Project Introduction
- Roles and Responsibilities
- Hardware Concept
- Major Accomplishments
- Overall Schedule
- Plans to and for Phase B
- Summary

Project Description Chart

James Webb Space Telescope Cryogenic Infrared Observatory at a Glance

- Mission Objective
  - Detailed study of the birth and evolution galaxies
  - Optimized for near infrared wavelength (0.6 –28 μm)
- Organization
  - Mission Lead: Goddard Space Flight Center
  - International collaboration with ESA & CSA
  - Prime Contractor: Northrop Grumman Space Technology
  - Instruments:
    - Near Infrared Camera (NIRCam) – Univ. of Arizona
    - Near Infrared Spectrometer (NIRSpec) – ESA
    - Mid-Infrared Instrument (MIRI) – JPL/ESA
    - Fine Guidance Sensor (FGS) – CSA





- Description
  - Approx. 6 m diameter deployable, active optics, primary mirror
  - Launched by Ariane 5 from Kourou, French Guiana, direct insertion to L2 orbit
  - Integrated Science Instrument Model (ISIM) consisting of 3 science instruments and a guider
- Website
  - www.JWST.nasa.gov

FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11
Formulation Phase (A/B)							Implementation Phase (C/D)					

Select Prime ▽ SRR ▽ NAR ▽ PDR ▽ CDR ▽ MOR ▽ Launch Timeframe ▽

Baseline Mission Success Criteria

- **Measure the space density of galaxies to a 2 micrometer flux density limit of 1.0 x 10^{-34} W $m^{-2}Hz^{-1}$ via imagery within the 0.6 to 27 micrometers spectral band to enable the determination of how this density varies as a function of their age and evolutionary state.**
- **Measure the spectra of at least 2500 galaxies with spectral resolutions of approximately 100 (over 0.6 to 5 micrometers) and 1000 (over 1 to 5 micrometers) and to a 2 micrometer emission line flux limit of 5.2x10^{-22} Wm^{-2} to enable determination of their redshift, metallicity, star formation rate, and ionization state of the intergalactic medium.**
- **Measure the physical and chemical properties of young stellar objects, circumstellar debris disks, extra-solar giant planets, and Solar System objects via spectroscopy, and imagery within the 0.6 to 27 micrometers spectral band to enable determination of how planetary systems form and evolve.**
- **Enable, within a 5-year mission, a total observing time of at least 1.1x10^{8} seconds on targets located at any position on the celestial sphere.**

Key Observatory Level 1 Specifications

- **Lifetime**
  - **The JWST spacecraft and instruments shall be designed for at least a 5-year lifetime. Level 1 performance shall be achieved for a minimum of 5 years.**
- **Telescope**
  - **The JWST Optical Telescope Element shall have a primary mirror whose unobscured light collecting area is no less than 25 square meters.**
- **Strehl Ratio**
  - **The Observatory, over the field of view (FOV) of the Near-Infrared Camera (NIRCam) shall be diffraction limited at 2 micrometers defined as having a Strehl Ratio greater than or equal to 0.8.**
- **Encircled Energy**
  - **The total encircled energy of an image of a point source over the FOV of the NIRCam shall be greater than 74 percent within a circle of 0.15 arc-second radius at a wavelength of 1 micrometers, and shall remain so over a period of 24 hours without intervention by ground command.**
- **Thermal Environment**
  - **The JWST Observatory shall provide the thermal environment needed to permit the imaging science instruments to be Zodiacal light background limited over the wavelength range 0.6 to 10 micrometers.**

Roles and Responsibilities

- **GSFC (Goddard Space Flight Center)**
  - Overall project management
  - Overall systems engineering
  - Leadership of Science Working Group (SWG) - Mather, chair
  - ISIM engineering, manufacturing and integration and test
  - Specific engineering responsibilities
- **NGST (Northrop Grumman Space Technologies)**
  - Observatory systems engineering
  - Observatory (OTE, spacecraft and ISIM) integration and test
  - OTE, spacecraft bus and sunshield design, manufacturing, integration and test
  - Launch site processing, observatory launch and commissioning
- **STScI (Space Telescope Science Institute)**
  - Ground systems development
  - Flight and science operations
  - Optics and instrument support

Roles and Responsibilities

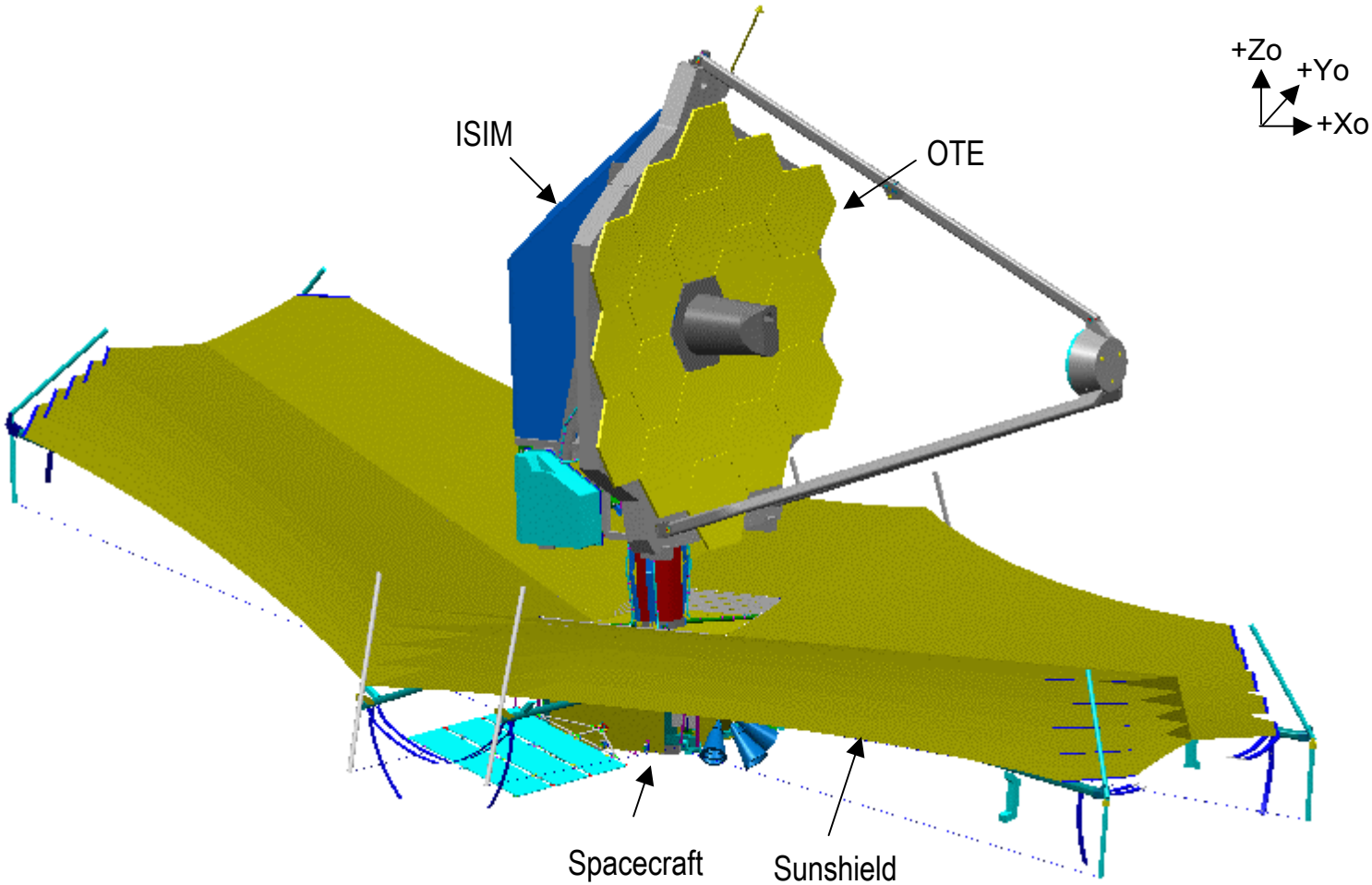
- **ESA/European Consortium**
  - NIRSpec Instrument
  - MIRI OBA (Optical Bench Assembly) and instrument integration and test
  - Ariane 5 launch vehicle
- **CSA**
  - FGS with tunable filter modules
- **UAz**
  - NIRCam instrument (LM ATC is prime); Rockwell provides detectors
- **JPL**
  - Overall MIRI management, systems engineering, flight software, FPA (focal plane assembly) /FPE (focal plane electronics) and cryostat (Dewar)
  - Wave Front Sensing and Control (WFS&C) technology development and oversight
- **MSFC**
  - Mirror technology development and testing
  - Environmental analysis
- **AMES**
  - Detector technology development

GSFC AETD* Responsibilities

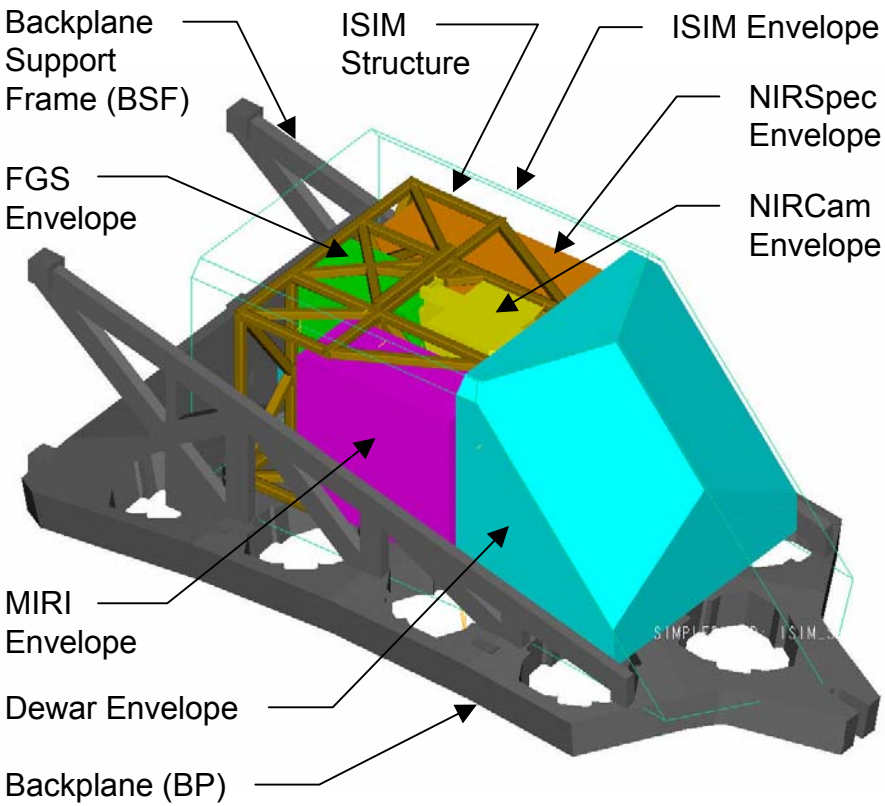
- IC&DH (Command and Data Handling System) with software
- ISIM (Integrated Science Instrument Module) Structure
- ISIM Engineering and I&T (Integration and Test)
- Micro Shutter Assembly (MSA) and electronics with software for NIRSpec
- NIRSpec detectors, detector electronics, software and harness
- OTE (Optical Telescope Element) technology program management and oversight
- Flight dynamics and mission planning

* AETD = Applied Engineering Technology Directorate

JWST Observatory



ISIM Instrument Overview



Near Infra-Red Camera (NIRCam)

- Detects first light
- 0.6 to 5 microns
- Includes Coronagraph Imaging Capability
- Supports Wavefront Sensing and Control
- FPAs passively cooled to 37K
- Univ. of AZ - LMATC instrument

Near Infra-Red Spectrometer (NIRSpec)

- Studies galaxy formation, clusters, chemical abundances, star formation, and kinematics
- 0.6 to 5 microns
- Simultaneous spectra of >100 objects
- Resolving powers of ~100 and ~1000
- FPA passively cooled to 37K
- ESA provided with NASA Detectors & Microshutter

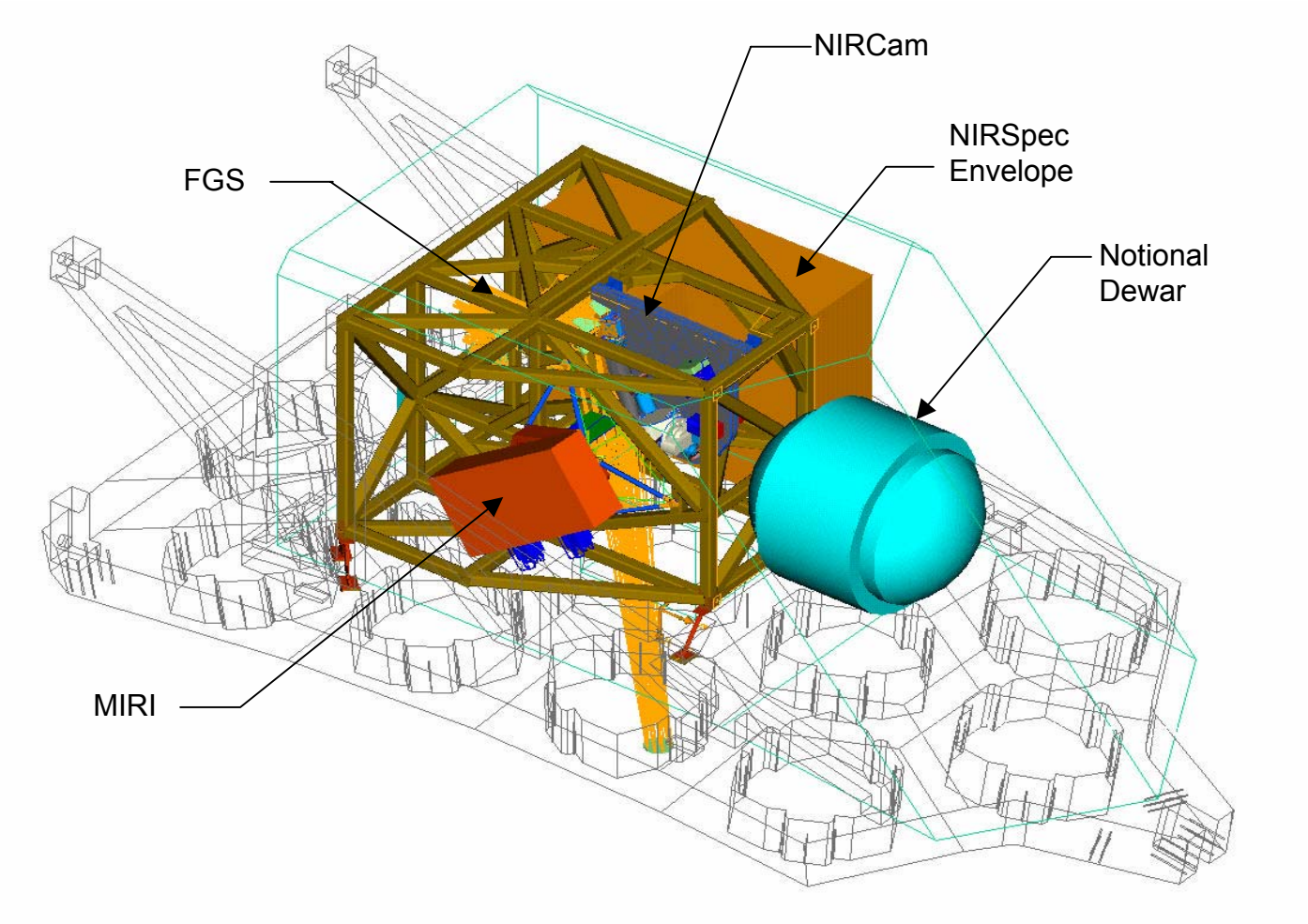
Mid-Infra-Red Instrument (MIRI)

- 100x sensitivity over previous systems
- Imaging and spectroscopy capability
- 5 to 28 microns
- Cooled to 7K by Dewar
- Combined ESA/NASA-JPL contributions

Fine Guidance Sensor (FGS)

- Ensures guide star availability with >95% probability at any point in the sky
- Includes Narrowband Imaging Tunable Filter Module
- CSA provided

ISIM Instrument Overview



Recent Accomplishments

- **Chose mirror segmentation (18 hexes)**
  - Better coronagraphic performance, lower schedule/fabrication risk
- **Decided to support each segment on a hexapod**
  - Lower risk, better imaging performance compared to baseline
- **Selected Be Mirror Technology on schedule!**
- **Chose 5-year (plus engineering margin) solid hydrogen cryostat (Dewar) for MIRI**
  - Lower cost
- **Completed Independent Cost Estimate (agreed with others)**
- **Began Phase B (detailed design) following Delta Mission Definition Review and Initial Confirmation Review**

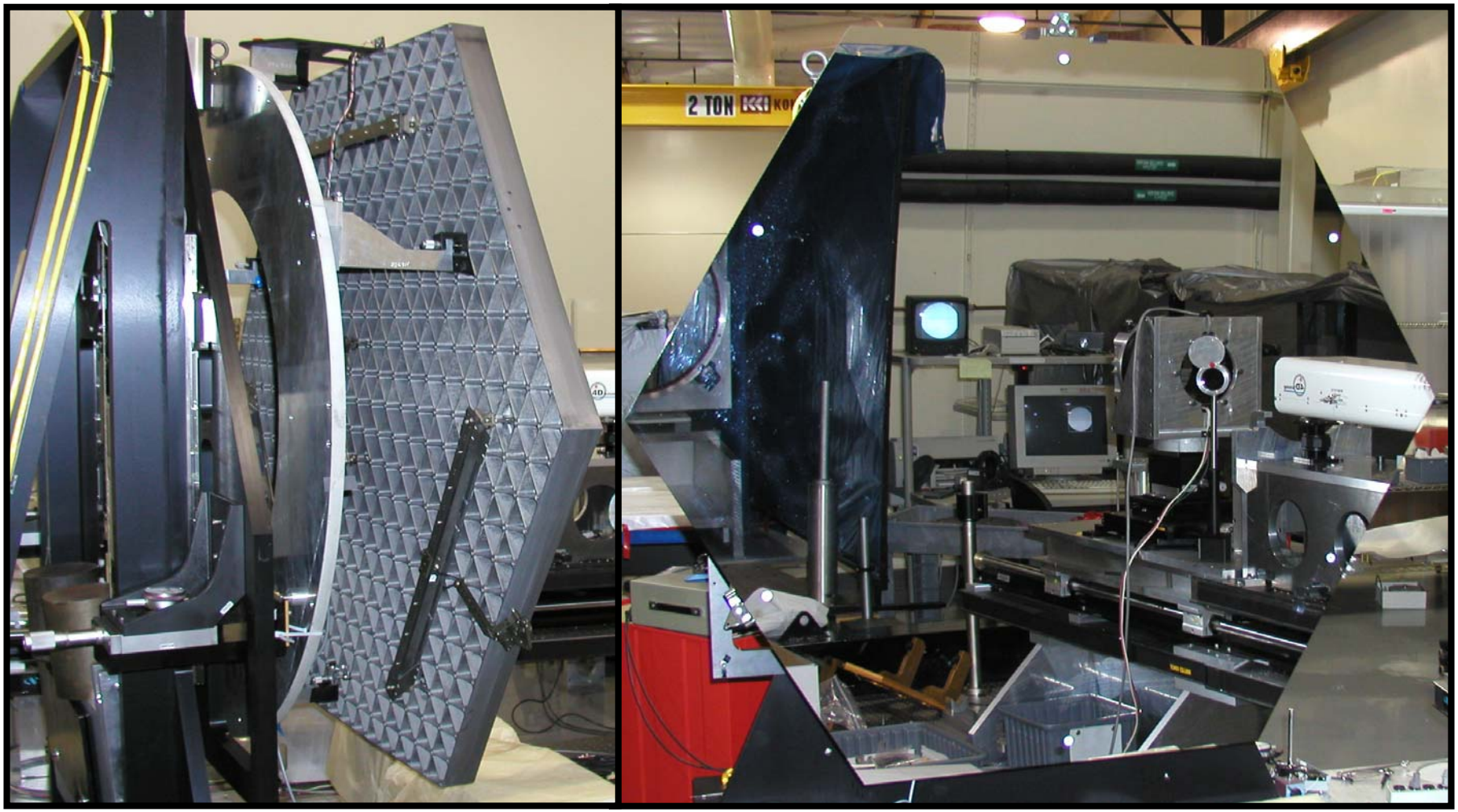
Recent Progress (2)

- **Chose mirror material (beryllium)**
  - Better image quality & stability @ cryo, lower technical risk
  - Longer lead times and fabrication schedules require careful management
  - ULE honeycomb sandwich had large figure changes
    - Ambient to cryogenic temperatures, and over operating range (35K – 55 K)
- **Finalized Level 1 requirements**
  - Updated sensitivity calculations to reflect telescope and instrument performance budgets
- **Got astronomical images with selected near IR detector prototype (HgCdTe)**
  - Meets NIRCam flight requirements, needs only package testing

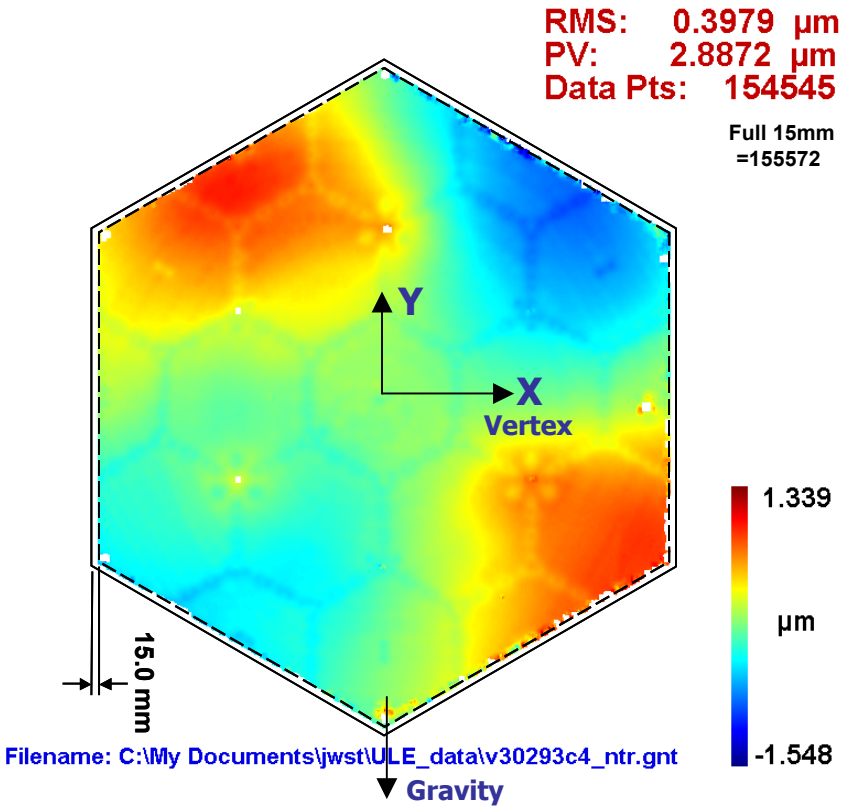
Recent Progress (3)

- **Increased angular pixel size for NIRSpec microshutter**
  - Reduced pixel count for lower risk, same shutter size (100x200 μm)
  - Improved throughput (lower diffraction losses)
- **On track for confirmation review, 12/03 Engineering documentation on track for System Requirements Reviews**
  - Mission level Dec. 16-19
  - NIRCam and MIRI Nov. 4-6
  - Fine Guider (FGS), January
- **ESA on track to issue call for proposals for NIRSpec in December**

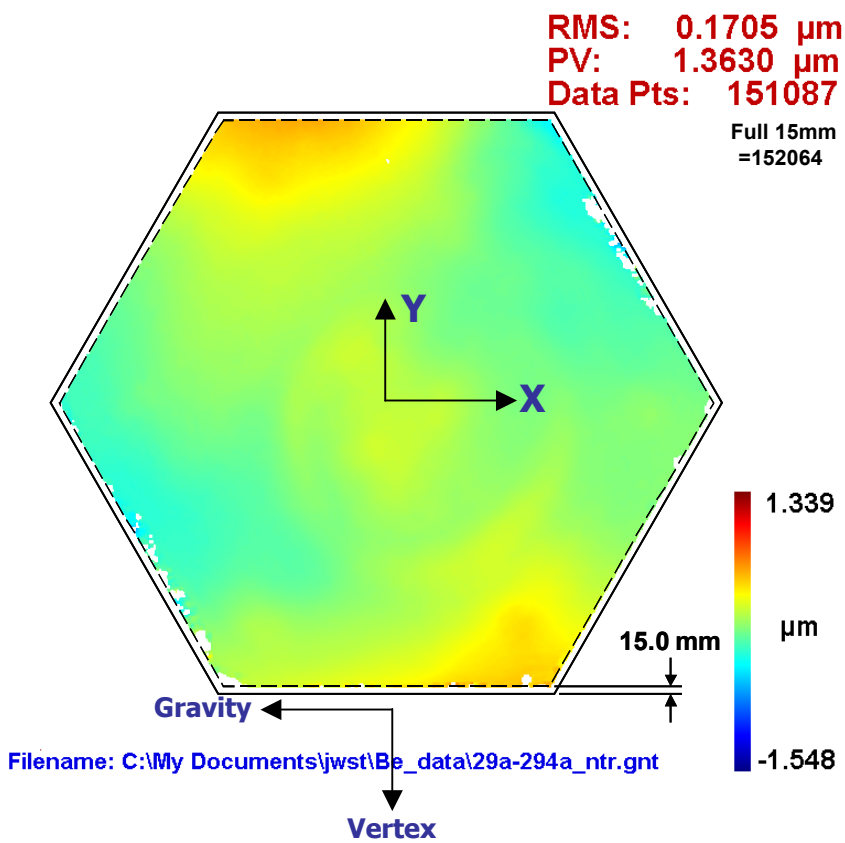
Ball AMSD II Be Mirror in Optical Test



~30 K minus Ambient



ULE

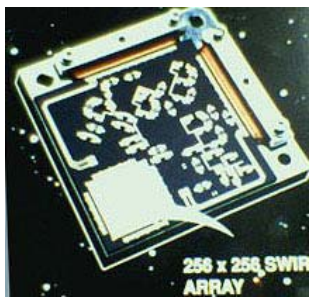


Be

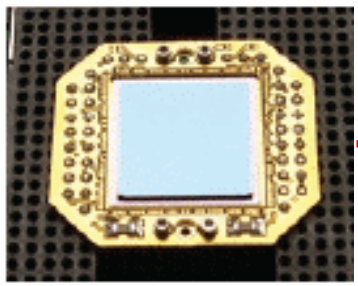
Detector Technology Development

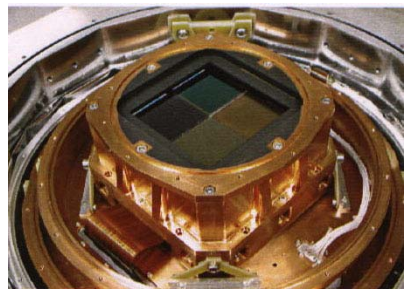
- NICMOS and IRAC arrays have demonstrated the basic detector architecture but with lower performance and smaller formats.
- TRL 4 achieved Feb 2002 with JWST performance levels achieved
- TRL 5 achieved Feb 2003 with JWST size 2Kx2K devices, mosaicing
- Astronomical Image with prototype, Sept. 2003
- **TRL 5 now, TRL 6 by March, 2005**

HgCdTe

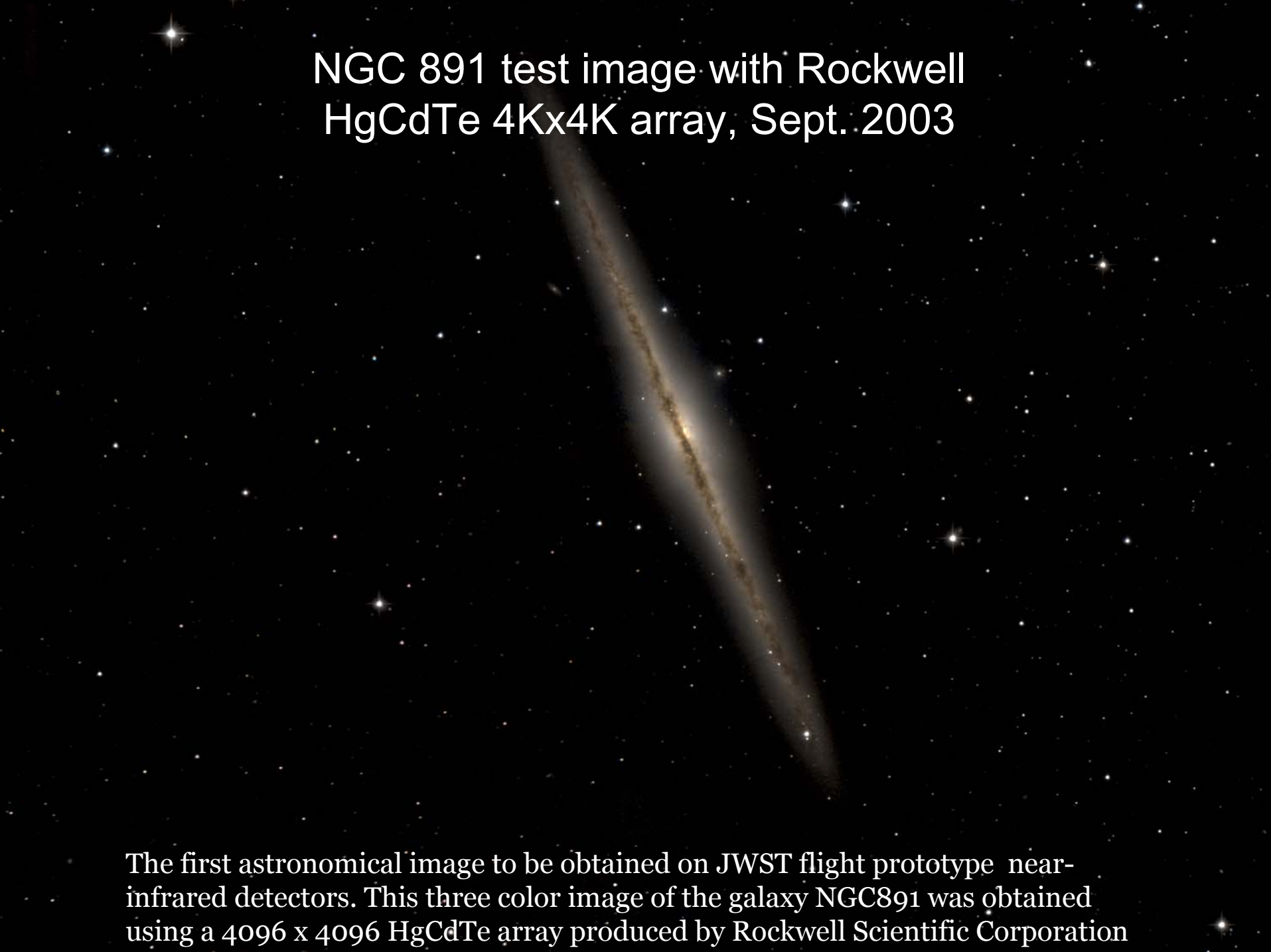


NICMOS 256x256


WFC3 1024x1024

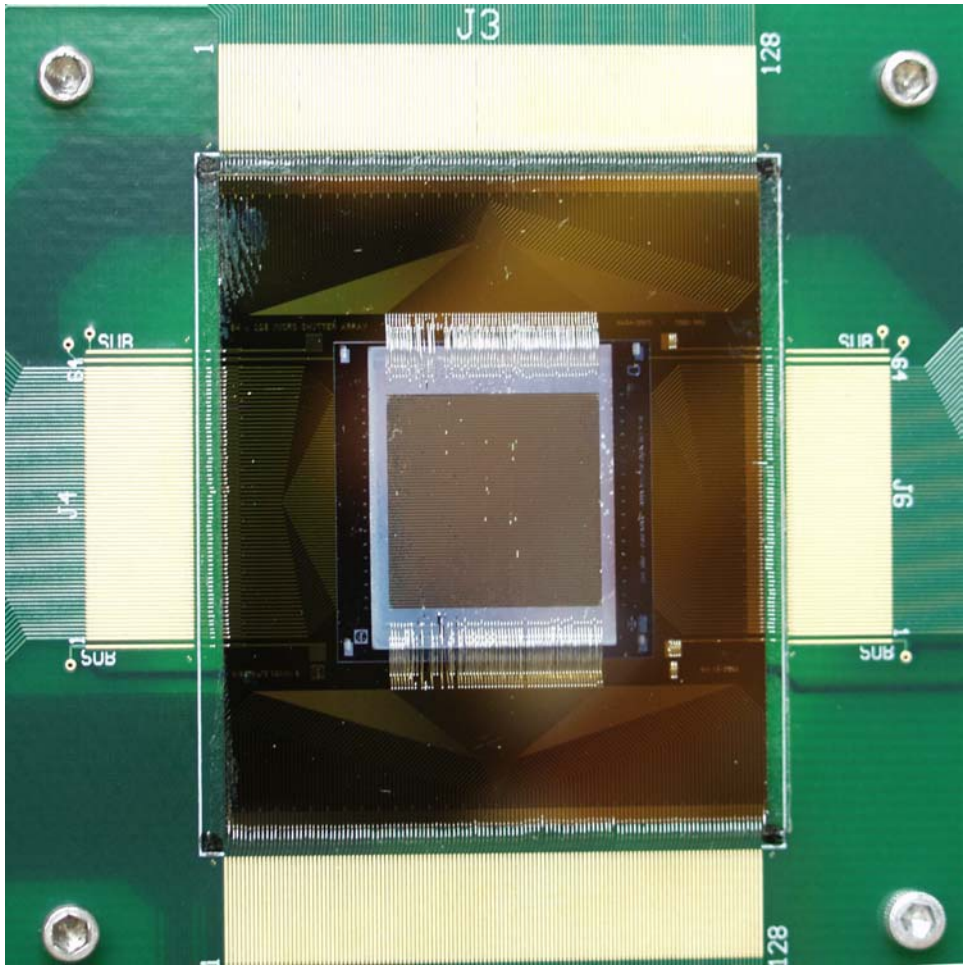

JWST Proto-type 4Kx4K

NGC 891 test image with Rockwell HgCdTe 4Kx4K array, Sept. 2003



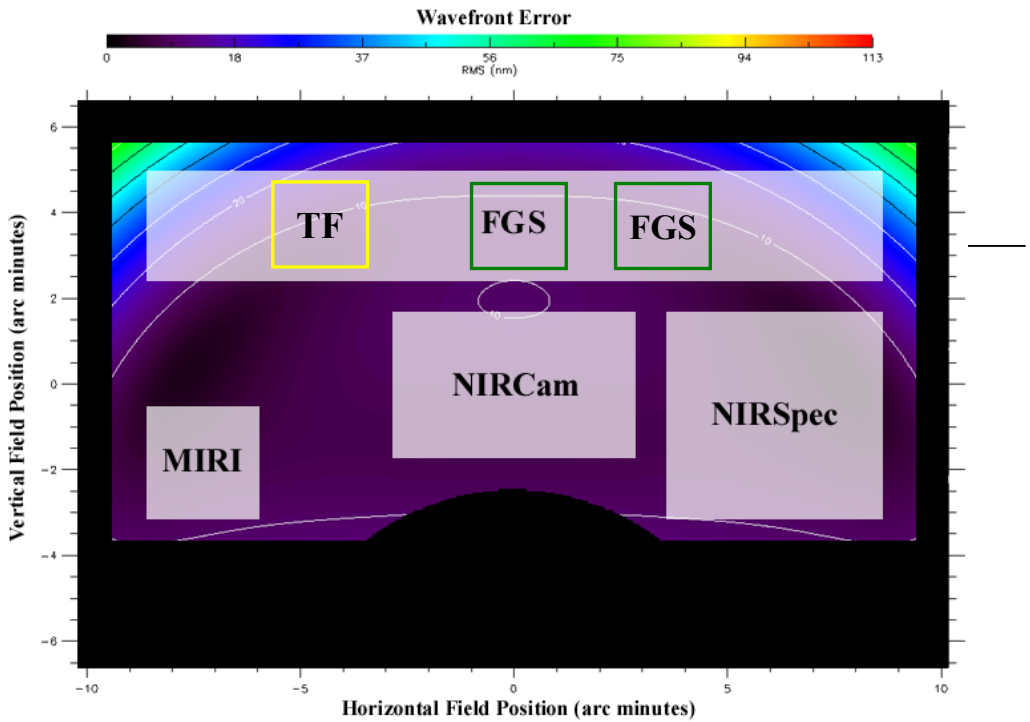
The first astronomical image to be obtained on JWST flight prototype near-infrared detectors. This three color image of the galaxy NGC891 was obtained using a 4096 x 4096 HgCdTe array produced by Rockwell Scientific Corporation

Microshutter Test Unit

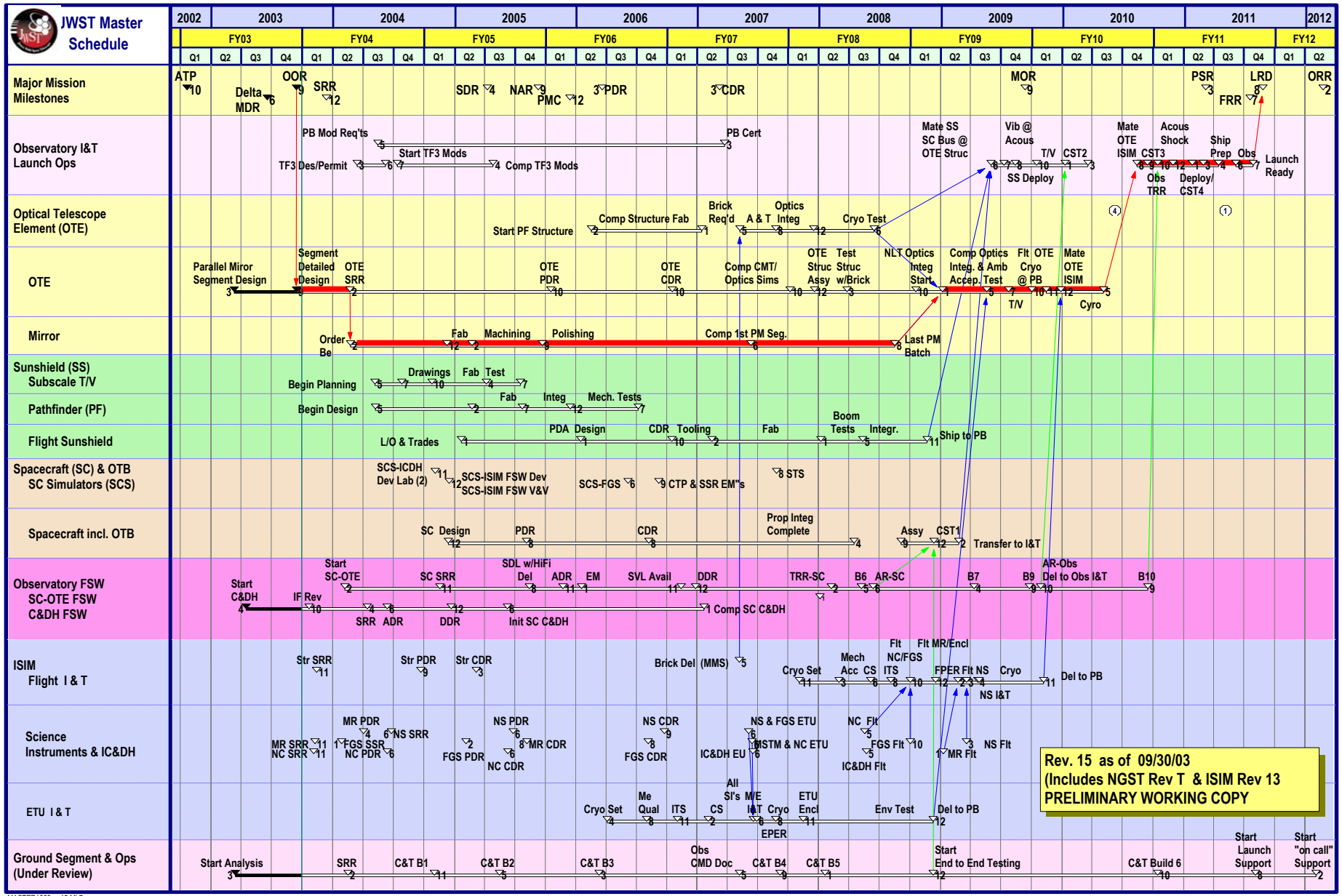


Focal Plane Layout

- **3 FGS fields of view in a central location.**
  - Two dedicated 2.3’ SCAs for guiding
  - Tunable Filter science (plus guiding capability) in third FOV, with two SCA’s and dichroic



JWST Master Schedule - No Change to Launch Date



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Plans for Phase B

- **Complete system trades**
  - MIRI and NIRCam SRRs (System Requirements Reviews) scheduled November 4-6
  - Observatory SRR scheduled for December 16-19, 2003
  - Ariane 5 interface definition
- **Complete instrument phase B studies**
  - ESA to select NIRSpec contractor and science
- **Start primary mirror segment fabrication**
- **Develop enabling technologies to TRL 6**
  - infrared detectors, lightweight primary mirror, image-based WFS&C, deployable sunshield and MEMS/MSA
- **Finalize descope plan (only level 1 remaining)**
- **Complete international MOU's**
- **Support Non Advocate Review (NAR)**

Summary

- **Significant recent accomplishments, major choices made**
- **Good technical progress**
- **NASA HQ approved transition to Phase B, based on independent cost analysis**